COMPREHENSIVE REVEGETATION PLAN

Relativistic Heavy Ion Collider

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Report Design/Layout

The Relativistic Heavy Ion Collider (RHIC) is located in the north central portion of Brookhaven National Laboratory (Figure 1). This facility consists of the circular Collider Ring, a relatively flat, excavated and scraped area immediately adjacent to the RHIC Ring intersected by a paved interior roadway, a 5 meter high slope and, above the slope, an interior woodland.

Figure 1 RHIC Location on BNL Property

GENERAL CONSIDERATIONS

The major goal of this plan is the stabilization of the sediments overlaying the RHIC Ring with vegetation. This is necessary in order to provide a sediment cover sufficient to assure adequate shielding of the ring. This may be accomplished by implementing the recommendations given in a later section of this plan.

This plan gives a number of recommendations where by the RHIC can be revegetated with species native to the Long

Island Pine Barrens. The area has, however, been subject to numerous revegetation efforts over the past twenty years. Most of these projects involved seeding with non-native species. It is to be noted that none of these species are found in the interior woodland at present. Thus, although it is ecologically prudent to revegetate the RHIC Ring with native species, the use of non-native forms could be used if the shielding of the ring is jeopardized. If this is the case, it should be viewed as an interim measure with the revegetation with native species as the long term goal.

In addition, areas immediately adjacent to the RHIC Ring have been excavated and scrapped during the various construction phases, while the interior woodland is largely undisturbed. These areas provide sites for ecological research and/or educational activities. This plan identifies these areas and discusses possible ecological research and educational opportunities.

SITE DESCRIPTION

For the purpose of this plan the RHIC has been subdivided into four management units. The RHIC Ring is considered to be Unit 1. Unit 2 is the excavated area bounded by the road and the RHIC Ring, while Unit 3 is the excavated area immediately adjacent to the woodland and bounded by the interior road. Unit 4 is the interior woodland(Figure 2).

Figure 2 RHIC Management Units.

Pink = Unit 1 Yellow = Unit 2 Clear =Unit 3 Blue = Unit 4

The interior woodland (Figure 3) is composed of pine-oak (*Pinus rigida-Quercus, spp.*) and oak-pine woodlands with an understory dominated by blueberry (*Vaccinium, spp.*) and huckleberry (*Gaylussacia baccata*) in the oak-pine woodland and scrub oak (*Q. ilicifolia*), with lesser amounts of blueberry-huckleberry in the pine-oak community. Sighting lanes were cut at various locations throughout the forest and are composed primarily of blueberry-huckleberry with little obvious recruitment of either pines or oaks (Black, 1998). Scattered throughout the western portion of this inner woodland are non-native evergreens, presumably seeded from trees planted by the CCC in the 1930s. Reschke (1990) gives the state and global ranking of all woodlands at BNL.

Figure 3 Unit 4, The interior woodland.

Unit 3 is the excavated area immediately adjacent to the interior woodland (Figure 4). This area is naturally revegetating with pitch pines (Naidu, et al., 1998). In places the water table is close to the surface and, during wet periods, intersects the surface in various locations forming intermittent ponds. When this occurs the pines are flooded and, as a result, often killed. The Sedge (*Scirpus cyperius*) and rush (*Juncus effusus*) generally indicate areas of high water table. Such sites are valuable ecological study areas that can be used by researchers to illustrate the effects of water table fluctuations on vegetation. Also valuable as study areas are those drier sites that are naturally revegetating. It is to be noted that there are presently several long-term ecological study areas located in Units 3 and 4.

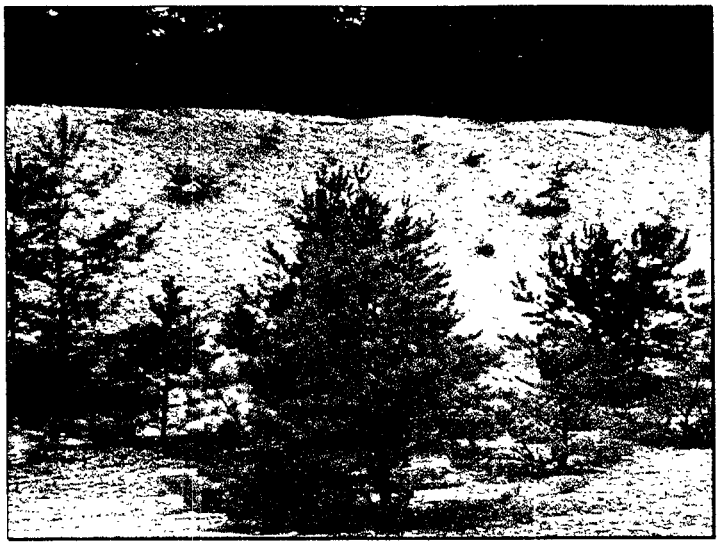

Figure 4 Natural revegatation is occurring in Unit 3

Note the poorly vegetated slope in the background

There are also permanent wetlands located within the areas of lower relief in Units 4 at the 1, 2 and 6 o'clock positions and in unit 3 at the same positions. These wetlands are associated with the Peconic River system and are, for the most part, relatively urdisturbed. Along the southern portion of Unit 3 there is a man-made canal containing large stands of the common reed (*Phragmites australis*).

This canal (Figure 5) extends from the road northward into Units 3 and 4 where there are three recharge basins used to accept cooling water from various lab facilities. At present two of these basins contain water and have a considerable growth of algae while the third is dry. Further to the north is a large grassy area with the stumps of several pines (Figure 6). It is assumed that this area was wooded at one time. Flooding resulting from the overflow of the recharge basins, then eliminated the trees. The area is presently at the grassland successional stage and has the potential for an additional ecological study site.

Figure 5. Canal with stand of *Phragmites*.

Figure 6. Previously flooded area. Note, dead pines

Along the western portions, the slopes leading up to the woodlands from Unit 3 have been reseeded with non-native grasses(Figure 7). In other sections, particularly along the southern portion, the slopes have not been seeded. Though these slopes are naturally revegetating with pine the process is slow, and erosion of the slopes is occurring (Figure 8).

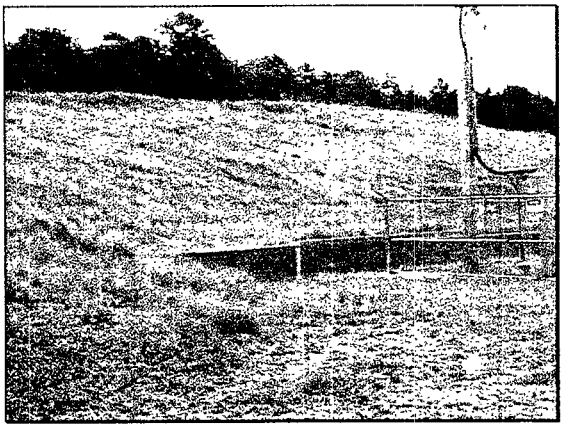

Figure 7. Area reseeded with non-native grasses

Figure 8. Erosion is common on the poorly vegetated slopes located between Units 3 and 4

Unit 2, the excavated area bounded by the road and RHIC Ring, is also naturally revegetating in several areas. As in Unit 3 there are moist areas where the water table intersects the surface during wet periods. The presence of sedges and rushes delineate these areas. There are also several barren areas that have recently been scraped in this Unit.

Unit 2 is subdivided into four subunits. The dominant vegetation in Subunit A is the pitch pine, which is in the process of revegetating naturally. There is, however, evidence of considerable off-road-vehicle (ORV) traffic in Unit 2 (Figure 9). Such traffic should be discouraged since it interferes with the natural revegetation in this area.

Figure 9 Note the effects of ORV traffic on revgetation in Unit 2.

Subunit B is an area of high water table and intermittent standing water (Figure 10). Sedges and rushes are the dominant forms in this subunit. Subunit C is a recently scraped barren area (Figure 11), while Subunit D consists of the developed sites within Unit 2 (Figure 12).

Figure 10. Sedges and rushes delineate Subunit B

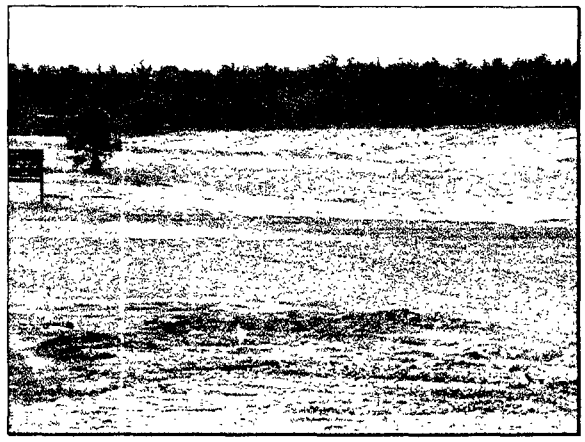

Figure 11. A barren area that has been scraped recently

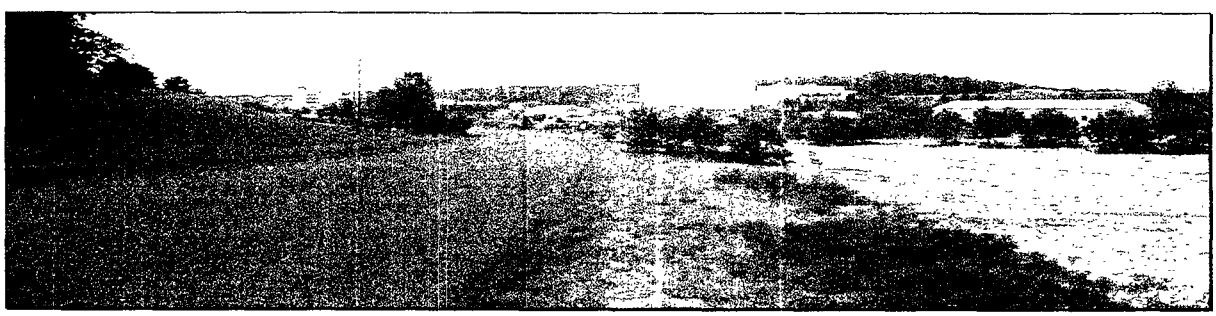

Figure 12. Subunit D a"typical" developed area

The RHIC Ring (Unit 1) is, for the most part, relatively well vegetated due to a combination of natural revgetation and various reseeding programs. Much of this area, however, has been planted with non-native vegetation, while a more recently seeded area has been planted with native species. There are, however, areas that are poorly or sparsely vegetated. In these areas gullies are forming and erosion is occurring (Figure 13).

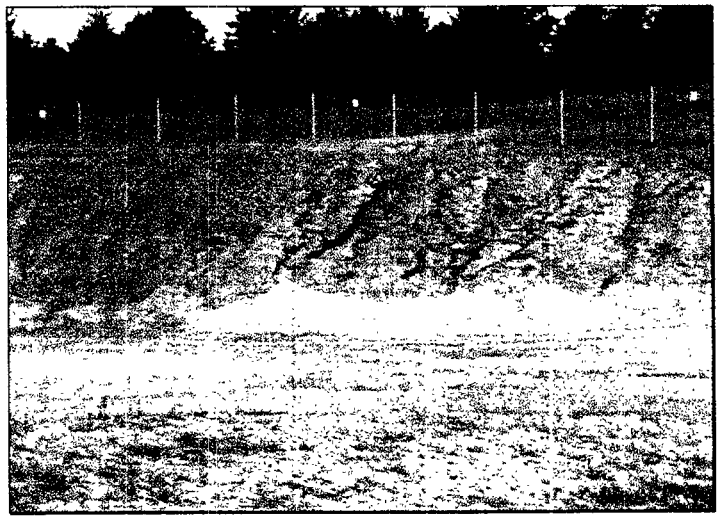

Figure 13. Erosion on the slopes of Unit 1

On the basis of the density of the extant vegetational cover, Unit 1 can be subdivided into three subunits. These subunits are, for the most part, small and fragmented. In addition gullies form rapidly during periods of moderate to heavy rainfall. As a result of the rapidly changing nature of the slopes in Unit 1 the area must be reevaluated frequently. Table 1 provides a method of evaluation based on the vegetative cover at any given section of the RHIC Ring and slopes. Figure 14 provides examples of poorly, moderately and well vegetated areas which, for the purposes of this plan, are considered to be subunits.

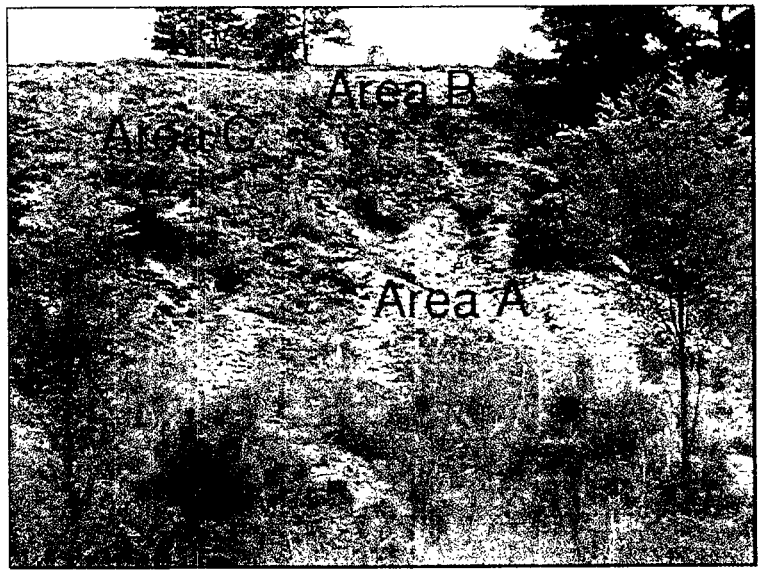

Figure14. Poorly(A), moderately(B), well (C) vegetated areas on the slopes of the RHIC Ring.

TABLE 1
Potential Erodability Based on Vegetational Cover

Area Examples	Plant Density	Classification	Potential Erodability
A	0-40%	poorly vegetated	high
B	40-70%	moderately vegetated	moderate
C	70-100%	well vegetated	low

There are numerous pines growing in Unit 1, particularly on the slopes of the RHIC Ring (Figure 15). In addition, the non-native black locust (*Robinia pseudoacacia*) is also common (Figure 16).

Figure 15. Pitch pines are common on the RHIC Ring

Figure 16. The non-native black locust on the RHIC Ring

RECOMMENDATIONS

UNIT 3-4

The woodland should remain undisturbed and serve as a long-term ecological study site. If invasive and/or non-native species are present or should they occur, they should be removed. The excavated area (Unit 3) should also remain undisturbed and serve as a study site where the effects of severe disturbance and resultant natural revegetation can be assessed. In addition, the area of high water table/ intermittent surface water is an equally valuable study site.

Ideally the slope noted previously that was seeded with non-native vegetation should be replanted with native grasses etc. following the removal of the non-native species. Should this be impractical this area could be planted with native materials interspersed with the existing non-native

vegetation, since it is possible that the native material may, over time, out-compete and eliminate the other forms.

UNIT 2

Unit two consists of the scraped area between the RHIC Ring and the roadway. Designated access points from the road to the RHIC Ring (Unit 1) should be established to prevent indiscriminate driving throughout this unit.

Four subunits compose Unit 2. As noted there is considerable natural revegetation in Subunit A. This subunit should be allowed to continue to revegetate naturally.

Subunit B is the area of high water table. This subunit should be allowed to revegetate and undergo natural succession. The drier slopes in this subunit could be planted with bayberry (*Myrica pensylvanica*) or allowed to revegetate naturally.

Subunit C consists of the recently scraped barren area in Unit 2. Four alternatives, in order of ecological/ educational value, are given for these areas:

1. Each barren area could be planted with distinct successional stages and serve as research/educational sites along with the woodlands of Unit 4 and the immediately adjacent area in Unit 3. For example, mosses and lichens could be planted in one section, grasses and sedges in another, a mixed grass-shrub land in a third, etc. These areas could then be maintained in that specific successional stage to illustrate biological successional stages.

   Duplicate plots should be developed and then be allowed to undergo natural succession to the woodland stage. Such plots would provide valuable data on the optimal successional stage at which to begin a restoration.

2. The excavated and recently scraped area to the south could be planted in native grasses and sedges to enhance nesting sites for avian grassland species and small mammals. Periodic mowing would be necessary to maintain these areas in the grassland successional stage. Mowing must be timed so as not interfere with courtship and nesting.

3. Additional habitat enhancement could be achieved by allowing portions of Unit 3 to remain unvegetated by periodic disking to remove vegetation. This would provide habitat for species such as killdeer (*Charadrius vociferus*).

4. Allow natural revegetation to occur. Based on data regarding the revegetation of similar areas at the RHIC and elsewhere it can be predicted that pines will invade these areas.

   Subunit C could also be subdivided and alternatives 1,2,3 simultaneously implemented on a smaller scale.

Subunit D consists of the developed areas in Unit 2. These areas could be more formally landscaped using a combination of native grasses, sedges, shrubs, pines and/or oaks.

Unit 1

Unit 1 consists of the RHIC ring and associated slopes. Previous revegetation efforts involved seeding with non-native vegetation. Presently there are areas where this vegetation is growing densely and other areas that are sparsely vegetated or barren. In these areas erosion is common. In addition, several of the dry wells on and adjacent to the ring have been recently excavated and require revegetation.

The primary purpose of revegetating the RHIC Ring and associated slopes is to stabilize the sediments covering the ring, thereby providing adequate shielding. Therefore, in those areas where erosion is occurring or is anticipated the rapid reestablishment of vegetation is of primary importance. Thus, the RHIC Ring should be inspected periodically to determine areas of active or potential erosion. Table 1 and Figure 14 can aid in identifying such areas.

Should erosion occur during the late fall, winter and/or early spring the reestablishment of vegetation will pose a problem since reseeding and/or planting is impractical. During these periods the shielding must be maintained by non-biological methods that will provide adequate cover until revegetation programs can be implemented.

As noted, the primary purpose of maintaining a vegetative cover is to stabilize the substrate in order to provide

adequate shielding of the RHIC Ring. Ideally the species to be planted should be native to the Long Island pine barrens (Appendix I). Should these species prove unsuitable from the aspect of providing rapid reestablishment of vegetative cover, it may be necessary, though from an ecological standpoint, less than optimal, to revegetate with non-native species. Should this be the case, a mixture of native and non-native seeds could be applied since it is possible that, over time, the native species will outcompete the non-native forms.

The revegetation of the above noted dry wells could serve as a mechanism to evaluate various management alternatives. The dry wells that have been excavated and are located within the slope of the RHIC Ring should be planted with non-native vegetation since this seed mix is known to provide adequate cover and maintenance of the shielding is primary importance. The remainder of the dry wells should be equally subdivided into two groups. The first group should be planted solely with native species while the other planted with a seed mix containing both native and non-native plants. By implementing this strategy, the preferred species to be planted could be determined for future revegetation efforts on the RHIC Ring. Thus, it may be possible over time, to establish a native cover for the RHIC Ring.

In addition to the above noted, the following general recommendations are given:

1) Since it is not feasible to remove the non-native species in densely populated areas these species, provided that they are not unduly invasive, could remain. When possible, however, native species should be encouraged. Therefore, it is recommended that an attempt be made to introduce native species by seeding or plug. It is possible that, over time, the native species could out-compete the non-native forms.

2) In areas where the non-native vegetation is less dense or sparse, seeding or plugging with native species could occur since, over time, it could be expected that these species would out compete the non-native forms.

3) Since the actively eroding areas are, for the most part, small, mechanical regrading may be impractical. An alternative may be the terracing of these areas. Properly designed, installed, and vegetated terraces would not only disperse surface runoff and reduce erosion, they

would also enhance the shielding of the RHIC Ring. Such terraces should be planted with native grasses.

4) It might also be possible to plant native seeds along with a rapidly growing cover crop such as winter wheat (*Triticum aestivum*). The cover crop would stabilize the substrate until the native seeds began to grow. At that time the cover crop could be eliminated by mowing.

It is to be noted that by implementing the above recommendations it may be possible, over the long term, to revegetate Unit 1 with native communities which is keeping with the management objectives of the Central Pine Barrens Commission. In addition, data obtained by implementing the recommendations regarding the revegetation of the dry wells would enable the proper selection of the revegetation alternatives given here.

SUMMARY

In addition to the obvious ecological benefits of the revegetation of the RHIC with native pine barrens communities, implementation of these recommendations will enhance the ecological and educational value of the RHIC, in particular and BNL in general. As noted, there are several study areas within Units 3 and 4. The sites in Unit 4 have been established to determine the long-term dynamics of a pine-oak and oak-pine forest as well as to assess the effects of clear-cutting on natural revegetation processes.

The sites in Unit 3 have been established to illustrate the effects of intermittent expression of surface water on pine barrens communities and to assess the natural revegetation of areas disturbed by both clearing and excavation. The only active management necessary in Units 3 and 4 would be the removal of invasive and/or non-native species (Appendix II).

By implementing various revegetation/restoration recommendations given for Units 1 and 2 a better understanding of restoration/revegetation methodology will be obtained. In addition, the plots planted at various successional stages would also be of educational value.

LITERATURE CITED

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APPENDIX I

SUGGESTED NATIVE PLANTINGS

In addition to the plants noted in this plan, the following are suitable for the revgetation on the RHIC Ring and for the grassland reestablishment in the other units. Additional suggestions may be found in the *Central Pine Barrens Comprehensive Land Use Plan* published by the Central Pine Barrens Joint Planning and Policy Commission, Great River, NY. The nomenclature is from Gleason and Conquist (1991).

Genus/species	**Common Name**
Festuca rubra	red fescue
Agrostis perennens	autumn bent grass
A. hyemalis Var. *scabra*	tickle grass
Aristida dichotoma	church-mouse-three-awn grass
Leptoloma cognatum	fall witch grass
Sorghastrum nutans	indian grass

It is to be noted that the NYS DEC has previously approved the use of these species at the RHIC.

Local sources of native plants and/or seeds are given below.

1) Bissett Nursery Corp. Holtsville, NY.

2) H.R. Talmage & Son, Riverhead, NY.

The New York State DEC operates the State Tree Nursery located in Saratoga Springs, NY. This facility is a source of various species native to Long Island.

In addition, suppliers such as Prairie Nursery of Westfield, Wisconsin can supply species native to Long Island such as little bluestem (*Schizachyrium scoparium*), etc. It is to be noted that, while the species may be native to Long Island, the actual plants will not be derived from the Long Island gene pool.

APPENDIX II

COMMON INVASIVE AND/OR NONNATIVE PLANTS

Genus/species	Common name	Present at RHIC
Polygonum cuspidatum	Japanese knotweed	no
Robinia pseudoarcacia	black locust	yes
Celastrus orbiculatus	Oriental bittersweet	no
Datura stramonium	Jimsonweed	yes
Lonicera japonica	Japanese honeysuckle	no
Artemisia vulgaris	mugwort	yes
Phragmites australis	common reed	yes

Note: *Phragmites australis* is the only plant native to Long Island. It is, however, invasive and should be controlled. Though not noted on the RHIC site, Japanese bittersweet and honeysuckle are present elsewhere at BNL.

APPENDIX III

ESTIMATED COSTS

The costs of implementation are difficult to assess since they are dependent on the actual revegetation scenarios implemented. It is recommended that the native grasses given in Appendix I be used in most revegetation efforts. The costs of these seeds are $500 per 30 pounds. It is estimated that 60 lbs of seed are needed to revegetate one acre. Thus the costs of seed per acre would be $1000. The costs of labor to prepare the substrate, etc. are not given here.

Representative prices for single species include
a) Little Bluestem $30.00/lb
b) Indian grass $15.00/lb